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THE GREAT JAPANESE VOLCANO ASO

By ROBERT ANDERSON

Reprinted from THE POPULAR SCIENCE MONTHLY, Vol. LXXI, July, 1907]

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THE GREAT JAPANESE VOLCANO ASO

BY ROBERT ANDERSON

WASHINGTON, D. C.

ASO-SAN, or Mount Aso, is a living volcano in the heart of the island Kiushiu, Japan, whose peaks rise to a height of several thousand feet out of a gigantic bowl. This bowl, which is many miles across, is an ancient crater surpassing in size all other known craters nearer than the moon. Some 5,000 people, grouped in half a hundred villages on the old floor, are living to-day, tilling the volcanic soil and trading in this vast crater, round about the base of the new and ever-active cone that has risen in it.

Kiushiu is the most southern of the four main islands in the Japanese archipelago. It is about 17,000 square miles in extent and is therefore larger than Vancouver Island, or almost equal in area to Massachusetts and New Hampshire combined. It is built up of very ancient rocks, both sedimentary and igneous, belonging to the paleozoic and mesozoic eras, as well as of younger rocks, and upon these as a foundation has been erected in more recent times, partly during the age of man, a superstructure of volcanic materials which now covers many thousand square miles, or about one half the area of the island. It contains twenty volcanoes, counting two that are just off the coast to the south, of which eight are now active. Among them Aso-san is on far the largest scale, though now it is in a decadent stage and is surpassed in activity by two or more of the others. Japan through all past ages has been a land of extraordinary geological activity, possessed of a vital energy which, continuing in force up to modern times, has been emphasized by the changes in level of its coasts and heralded by its ever-vigorous volcanoes. It is far from being a land solely of volcanoes and volcanic formations, as is sometimes thought, for these assume insignificance when compared with the wide areas and great thicknesses of strata that are representative of almost every stage of the geological column. But that it is a country of great volcanoes there can be no doubt. They have flourished ever since the beginning of its geological history and to-day there are 164 independent volcanic cones, or colonies of related cones, scattered through the Japanese islands, including the Kuriles and the Liu Kiu chains. Of this number 54 are now actively grumbling and nursing their wrath and occasionally losing all control. Fuji-san and Aso-san are the kings, although others surpass them in destructive activity. The first is famed for the height and regularity of its cone as one among the preeminently symmetrical and beautiful volcanoes of the

world. The other is almost unknown except among the Japanese, although its immense crater is the largest of all that have yet been found on this globe.

The center of Kiushiu is about 600 miles distant from Yokohama and Tokio by the ordinary routes of travel, and by far the best way to reach Aso-san is from Nagasaki, whence one of two routes may be followed—either far around from the peninsula on which Nagasaki is situated, a distance of 150 miles by railroad to Kumamoto, a city on the west coast of Kiushiu, within 25 miles of the volcano, or most of the way by sea, a distance of 75 miles to the same city.

The pilgrim or traveler who mounts to the walls of the castle of Kumamoto and looks eastward over the green and gardened city and over the rich plain bordering the bay of Shimabara, off to the mountains that form the backbone of the island, sees the massive, sacred, god-mountain Aso above a long blue chain. A thrill passes through him as he sees a white cloud streamer waft horizontally across the grey clouds around the summit or, rolling into a ball, float upward like a thistle-down. The white cloud is soon dissipated, but another born from the mountain takes its place as soon, and one knows that here is a volcano, that the god of the mountain is alive. Hundreds of Japanese visit Aso-san every year to pay their homage to the deity that the mountain represents, but only rarely has it been visited by foreigners.¹

During the spring of 1905 the writer and his brother, Malcolm Anderson, and their friend, Kiyoshi Kanai, spent several weeks in the vicinity of Aso-san, staying for many days in one of the villages in the old crater, living in native Japanese fashion and coming in touch with the spirit of the people and the natural history of the region. The way from the west coast to the mountain lies across the Kumamoto plain among little open fields that in the spring are richly colored with deep green wheat and yellow mustard, along a broad avenue eighty feet wide marshaled by stately cryptomeria trees whose handsome bark and foliage remind one of their big cousins—the California redwoods. Beyond the village of Seta at the edge of the lowland, some 13 miles from Kumamoto, one is led up into the mountains by a gentle ascent, the volcano itself being all this time hidden by the intervening slopes. But a backward view reveals the lesser volcano Kimbo-san rising as an independent cone near the sea, and if the day affords one of the clear Japanese skies, which unfortunately are only too rare but which are so beautiful when they come, one sees the

¹ The only mention of Aso and its crater that the writer knows of is in an article by the geologist, John Milne, in *The Popular Science Review*, New Series, Vol. IV., No. 16, October, 1890, and in Murray's 'Handbook for Japan,' by Chamberlain and Mason. The former is an English periodical that has long since ceased publication.

great destructive volcano Unzen-dake springing up to nearly 5,000 feet on the peninsula of Shimabara over across the gulf. One travels to Aso-san as one chooses, either on foot, in a jinrikisha, or in the funny little perambulating dry-goods box known as a *basha*, the Japanese adaptation of the English stagecoach. We preferred to walk, and upon leaving the plain we enjoyed many picturesque miles up the cascading stream Shirakawa. For the first night out from Kumamoto we stopped at a modest little inn, being driven by a pouring rain to take shelter at the hamlet of Tateno, which is perched high up on the side of the canyon that the road follows, at an elevation of about 1,200 feet above the sea. From there on the canyon of the Shirakawa becomes more precipitous in outline, and a short tramp in the early morning along the mountain slopes above it brought us to its brink at a point where it forked and cut squarely across our path. Here, pillared walls formed of roughly columnar lava, through which the stream has cut a grand gorge, drop sheer several hundred feet, and the path descends a zigzag course to their foot, where the two forks toss into one stream over a boulder-strewn bed. Near here a hot saline spring surrounded by the hamlet of Tochinoki, where many bathers come, give the first evidence of the proximity of the volcanic center.

Whichever of the two forking streams one follows, one presently comes up upon a broad plain that is surrounded by heights on every side and that curves around in the form of a great crescent. But, instead of ordinary mountains, the outer convex curve of the crescent is ringed about with an even-topped wall rising on the average about 1,500 feet, while the concave side is bordered by a great rugged mountain mass attaining a height of over 4,000 feet above the plain. The configuration of the region is absolutely unique and one is at a loss to understand its significance until later on, climbing the mountains and gaining expansive views over the whole broad domain of Aso. The truth is this: That a vast oval crater basin occupies the region, but is divided in two by a range of mountains that has risen across its center diametrically. The two portions of the crater thus cut off are the two crescent-shaped plains, whose level bottoms are formed by the old crater floor, whose outer surrounding walls are its rim, while the inner side of each is walled in by the great dividing range. There is but one opening in the ramparts hemming in these basins. It is where the western end of the central range meets the bounding wall. Each of the two halves of the crater is drained by a stream, and these small rivers uniting around the base of the central range at this western end, flow through the common outlet—the grand gateway through which we made our entrance. It is 10 miles across the crater from west to east in the diameter occupied by the dividing mountain ridge, while from wall to wall from south to north it is 14 miles. These figures, it must be stated, are only estimates, but a

number have agreed that they are approximately correct. The oval area occupied by this volcanic bowl is thus over 100 square miles, an area half as large again as the District of Columbia.

The crater of Aso is both for size and structure unique among the craters of the world. The Hawaiian volcanoes, with which Aso shows the most resemblance, are of greater bulk, but their craters, which are usually spoken of as the largest in the world, can not compare in size with that of Aso. The crater of Haleakala, according to Dana, is $7\frac{1}{2}$ by $2\frac{1}{4}$ miles in dimensions, and covers some 16 square miles. It has a greatest depth of 2,500 feet. The Kilauea crater, Dutton gives as $3\frac{1}{2}$ miles long by $2\frac{1}{2}$ miles wide and from 300 to 700 feet deep. The crater of Mauna Loa was measured by Alexander as $3\frac{1}{2}$ by $1\frac{3}{4}$ miles in dimensions, with an area of $3\frac{1}{2}$ square miles. The islands of Santorin south of Greece in the Mediterranean preserve the remains of a crater 18 miles in circumference, and Pantellaria, between Sicily and Africa, one with dimensions of 8 miles by 6. The two Italian crater lakes, Bolsena and Bracciano, are of great size; the one is oval with a long diameter of 9 and a short diameter of $7\frac{1}{2}$ miles, and the other is a circle 6 miles wide. The crater of the volcano Palandökan in Armenia is said by Bonney to be 6 miles in width. Among the volcanoes of the Canary Islands, Scrope mentions the cirque of Teneriffe, which contains a pit 2,000 feet deep and a high peak within it, as being 8 miles long by 6 miles wide, and Bonney the crater on the island of Palma as 9 miles in diameter. A crater on Mauritius is said by Dana to have a longest diameter of 13 miles. Among the great volcanoes of Java, according to Scrope, Papandayang has a crater with measurements of 15 by 6 miles, and Bromo one with diameter of 4 or 5 miles. Crater Lake in Oregon, described by Diller, is one of the most perfect. This nearly round pit is 4 or 5 by 6 miles in dimensions and has a depth of 4,000 feet. But Aso surpasses them all, with a crater equaling 2 or 3 times the combined volumes of the three great Hawaiian craters mentioned.

The journey over the old floor in the midst of such novel surroundings is a unique and pleasing one, but the stupendousness of the scene comes over one more strongly when he looks down upon it later from above. Our little party chose the southern of the two forks and followed it up for mile after mile along its gentle upper course. The distances proved elusive. We looked across the plain to the wall on the other side and it was only a little way, but still as we went the goal seemed no nearer. The ascent from the point of outlet of the streams is at first rather steep. Within about a mile, however, the fork that we followed bursts off the level of the crater floor in a picturesque waterfall. It is called by the Japanese *Aigaeri*, or "trout-return," for beyond this the fish can ascend the stream no farther. The view upward to the mountains surrounding the plain on all sides is mag-



FIG. 1. THE CASTLE AT KUMAMOTO WITH ITS STRONG, UNCEMENTED MASONRY WALLS, BUILT THREE CENTURIES AGO. This style of construction requires a slope to the walls. The author and his brother ran a race to their top and found it quite possible to scale them. The superstructure of the castle was almost destroyed during the Satsuma rebellion in 1877. The view of Aso from the single remaining turret is magnificent.



FIG. 2. HOT SPRINGS AT YUNATANI NEAR THE WESTERN END OF THE ASO RANGE. There is a small geyser here that spouts out boiling water and red mud.

VOL. LXXI.—3



FIG. 3. PANORAMIC VIEW OF THE HIGHEST PORTION OF THE RANGE IN THE CENTER OF the highest peak of Aso-san. On the right is Neko-dake. Photo by Malcolm Anderson.

nificent as one journeys on over the gently rolling surface of the basin floor. To the southwest the ring wall, elsewhere comparatively level-topped, rises up into mountain peaks that are between 2,500 and 3,000 feet higher than the level of the plain. To the north and northeast run the mountains that form the barrier between the two halves of the crater. They make up one massive, rugged ridge whose summit is broken by several dominating peaks. It is this range or ridge that is named Aso-san. On the summit, but at the foot of the highest peaks, at a point about half way from end to end of the Aso ridge, is situated the modern active crater from which rose the cloud that we saw from Kumamoto. A view of the rising steam puffs is again obtained as one comes out into the widening plain above the waterfall. And as one goes farther and finally reaches the central and widest portion the view of the Aso range, which was at first an endwise one and eastward, opens out until one looks to the north upon it broadside. There are three main peaks and many minor ones, the most striking of them being Neko-dake at the farther, eastern end. Its slopes have the graceful curving outlines characteristic of volcanic cones, and its summit is a jagged battlement of monumental lava pinacles looking somewhat as if they might be the remnants of a shattered crater. Its eastern flank drops down and ends the range by blending with the converging outer walls of the two basins. The next nearest peak is Taka-dake, a higher although less distinctive summit forming the culmination of the range. It is separated from



THE CRATER, looking north across the southern half of the crater. In the center is Taka-dake

Neko-dake by a depression of about 2,500 feet, out of which both mountains rise steeply. The ridge almost loses its continuity in this depression, so that Neko-dake is left as an isolated pyramid with truncated broken summit rising about 2,500 feet out of the highest part of the old crater to an elevation of 4,800 above the level of the sea. Taka-dake on the west side of the gap has an altitude of 5,600 feet above the sea, and is about 4,000 feet above the crater floor around its base, and some 4,500 feet higher than the point where the two streams have their outlet. On the southwest flank of Taka-dake rises the half-dome summit of a third peak, Naka-dake, facing the southern basin with vertical cliffs of black rock that have the appearance of being the cross section of a lava flow. It is from a low point of the range west of this summit that the steam cloud issues from the small modern crater, whose cone is hidden from the southern basin by an outstretched flank of Naka-dake. West of the new crater is another low place which divides the highest portion of Aso from the continuation westward. This gap is about equidistant from the two ends of the range. West of it rise subordinate peaks along the ridge, which gradually sinks lower until it comes to an end near the outlet of the streams. The distance from west to east across the big crater of Aso along the line occupied by the central range is about ten miles. But following the curving course of the crescent basin it is much farther from one side to the other. By the road through the middle of the plain the distance is about eighteen miles. Our little party after

passing through many hamlets and villages between long rows of small houses that line this main thoroughfare, at last, at a distance of twelve or thirteen miles from the stream outlet, reached Takamori which we had chosen as our goal. This is a prosperous small town with several hundred inhabitants, the chief center for the rich agricultural district hemmed within the volcanic heights of this southern half of the old crater.

This whole district is one wide expanse of cultivated fields, a mosaic of little patches differently planted, unfenced and unbounded, stretching freely down the plain in endless kaleidoscopic variety. In the spring-



FIG. 4. LOOKING SOUTHWEST ACROSS THE FLOOR OF THE SOUTHERN HALF OF THE ASO CRATER AT A MUCH WORN PORTION OF THE SURROUNDING WALL. The town of Takamori shows as a spot of white in the distance on the left. Photo by Malcolm Anderson.

time wheat and mustard, growing tall and vigorously, are the dominating crops, and the rich green of the grain mingled with the brilliant yellow of the mustard blossoms spreads a gay succession of tints over the wide plain. Here and there a tree, or a cluster or line of trees, for the most part dark pines or phantom bamboo groves, give a picturesque irregularity to the vast chess-board, standing like players on the light squares or the dark. The villages and groups of farm-homesteads with their conically roofed thatches appear as small as ant-hill colonies when viewed from above from one of the innumerable points of vantage round about, so small are they as compared with the breadth and depth and largeness of the scene of which they are a part.

On a day in April that dawned cloudless and with a frosty chill the writer set out to reach the summit of Neko-dake, the ragged-topped mountain at the eastern end of the Aso chain. As I went among the little fields and along the hedgerows in the early morning, always choosing among many paths one that seemed to lead me eastward, for beyond Takamori no well-beaten road continues farther up the plain, I met several people setting out also for the day. Each one of them looked with wonder at me, a stranger, staring with curiosity but bowing courteously in reply to a morning's greeting. One was a man with his faded bluish-grey kimono tucked up above his knees, leaving displayed a considerable expanse of underwear, his calves swaddled in blue-canvas walking gaiters above the straw sandals on his feet, and his shoulders wrapped in a bright red blanket—a man with the worn brown countenance of a country traveler shaded by a sun-darkened straw hat. He was a type of wayfarer often seen in the out-of-the-way portions of Japan, who, touched by an expanding arc of the great wave of westernization, has adopted a ludicrous cross between the native and foreign dress, a cross that possesses all the characteristics of degeneracy from both of the parent stocks. The next man that passed carried on his shoulder a short wooden steel-bound mattock or hoe, such as the peasants use in cultivating the fields, and another led a bull stout of neck and sullen of countenance laden with a rough plow and other tools for the day's work. These men were coming from their homes out to the particular little patches belonging to them somewhere in the plain. It is customary for the peasants to group their houses in small colonies and sometimes they go long distances to their work. Still another man, who came along the path empty-handed and empty-faced and out of work, was evidently quite resigned to the enforced leisure promising for that day. As I went farther and the day grew the fields became peopled here and there with men and women in small groups heartily beginning their task of digging and planting and nursing the ground. This is their daily occupation and so they live on peacefully, paying no heed to the filmy cloud floating over the crest of the Aso ridge, which now disperses before the spring sun only to return, in one form or another as a misty veil over the mountain top, a dark smoke, or a silvery cumulus cloud standing bright on the blue sky. There is no thought of the living force of the volcano.

The crater floor slopes upward from the outlet toward the east, and Takamori is several hundred feet higher than the level of the floor near the break in the walls where the streams flow out. It rises still more beyond Takamori and breaks from a fairly even plain into undulating hillocks which occupy the angle where the outer wall curving in converges with the Aso range. In this angle I reached the base of Neko-dake and the foot of the wall at the same time. The ascent was up a grass-grown ridge having an even slope of thirty degrees, but becoming

narrow and ragged as it approached the rocky mountain top. At an elevation of 4,750 feet by my barometer, just under the brow of the summit, I caught a glimpse on approaching of what I took to be a lonely wild cherry tree in blossom far up here alone. It proved to be a group of bushes with their bare limbs and twigs bearing little balls of snow, remnants of the winter.

From the mountain top a magnificent view opened and led me for the first time to a comprehension of the structure of the region. I had come from a deep basin on the south of the Aso range and here suddenly was spread out on the north its almost exact counterpart. At about 3,000 feet below the peak on which I stood lay this other far-reaching plain which seemed to be the continuation of the southern one, while round its outer edge it was enclosed by a similar curving wall. The grandeur of the scale upon which all the lines in the scene were drawn made the outlook a most impressive one, and with the view came a sense of the magnitude of the forces that had been at work in molding the large details of such a landscape. The sight was such that it carried with it at once the appreciation of these two huge bowls as parts of a great crater, divided by a high, massive mountain partition.

This crater is almost circular in appearance. Its rim forms a smooth sweeping curve around the whole circumference, broken only at the cleft on the west where the streams pass out, and on the east where it is joined by the slope of Neko-dake. The summit of this outer wall is remarkably even and its inner side precipitous. Although it presents rocky precipices at points on its face, its general slope is by no means perpendicular, but, being steeper as a rule than ordinary mountain slopes, it has a strikingly abrupt appearance. This is especially true in the case of the northern basin, where the wall facing the south is less gashed by lines of erosion, is more sheer, and has a more perfectly preserved even summit than the wall of the southern bowl. The latter wall is furrowed by gulches that have eaten back to the summit in places and notched the sky-line of the rim. Between these gulches sharp ridges run out into the plain, some of them looking more like lava flows descending from the wall than like remnants left by erosion. Such ridges run out into the northern basin as well, and little island-like hills rise in isolated positions from the crater floor. This half, though a close counterpart of the other, is more nearly round and its walls preserve a more even height. The slope up from the floor in both basins is gentle at first at the foot of the walls and then becomes steep. The walls are formed of roughly bedded lava flows interstratified and intermingled with mixtures of vesicular lava, scoria, pumice and volcanic sand. The harder lava layers project with vertical rocky faces, while between them softer zones have weathered away into débris slopes and produced a rough terraced effect, somewhat similar to that in the sides of the Grand Canyon of the Colorado. The height of the

walls above the level of the plain is on the average about 1,500 feet. It decreases toward the western side owing to the gradual rise of the floor in that direction, but increases at some points, as on the southwest and west sides, where mountains break the continuity of the horizon line.

From the brink of the wall around the whole circumference of the big crater, a wide plateau slopes gently away at an angle of only some five to eight degrees. One is apt to think of a crater as a pit on the apex of a sharp conical mountain. The crater of Aso has a cone, but its slopes are so moderate that one realizes only from a point of comprehensive outlook that this vast open bowl lies on the summit of a huge mound, which forms an upland of low relief in the center of Kiushiu.

The outward-sloping surface of this mound, as seen from above, is like a plateau, but it is without a single level place. No surface could be more wrinkled and still preserve the appearance of an inclined plane. It is completely made up of knolls and ridges and knobs, which continue off for many miles to the base of high encircling mountains. From the summit of Neko-dake these distant mountains are seen to surround this upland, much as the walls of the big crater surround its floor. The hillocks of the upland are overgrown in the early spring with long dry grass, but the cultivated bottoms between shine like emeralds, the green of the wheat being deepened here and there by the background of black soil upon which it grows.

From the peaks of the Aso range that divide the two well-populated plains long flowing ridges with concave slopes reach down into the floor. Between them are steep gorges. These ridges are not dwelt upon nor cultivated, probably on account of the lack of water, but like the hills of the outer plateau are grown over with rank grass. They contrast strongly with the richly tinted sweep of the crater bottoms. Considerable patches of the northern plain are sometimes flooded, and there is a legend that the big bowl of Aso was once occupied by a lake until a god kicked the hole in the wall to let the water out and leave the ground for cultivation. One can not but admire the conception of the ease and despatch with which this early piece of reclamation work was carried out.

Nearly all that has been described, and more, can be seen from the top of Neko-dake; so much, in fact, that two or three hours spent on the summit was all too short a time. The descent was quick down the steep slope, but the evening homeward jaunt to Takamori was one of many miles. The way led along a muddy black path; at first among bare fields, where peasant women had been at work all day gathering up corn stalks, loading them on oxen, and sending them home to be chopped up to feed the animals; and then among the endless paddy-fields of wheat and mustard. Finally 'home,' when reached, consisted



FIG. 5. THE MODERN MUD-CONE OF ASO-SAN WITH VAPORS ISSUING FROM THE NEW CRATER. In the foreground is a temple to the God Aso.

of a floor, a few bowls of rice, and a bath through which a dozen men had been before.

On another day the three of us set out for the modern crater. A walk of a few miles brought us to the village of Yoshida about opposite the central portion of the Aso range, whence a feasible way seemed to offer up to the low place in the range already noted. It led first over the end of a number of low ridges that radiate into the plain from the central mountains and then up an easy grassy slope to the top. Here we had expected a divide that would enable us to look over into the northern basin, but instead we found an expanse of almost level mound-strewn country mostly enclosed by the higher portions of the summit

and so wide that it intercepted all view. The mounds covering this upland were seemingly formed of soft volcanic *débris* and presented a straggling appearance. This summit country sloped upward on the east within less than a mile into a low cone some few hundred feet high, from which the steam clouds poured forth. Behind it on the southeast rose the forbidding-looking crags of Nakadake and on the east the flanks of Taka-dake to a much greater altitude.

At the foot of the cone on the desert-looking slope stood several huts and two small temples, one Buddhist and the other Shinto, built in honor of the god of Aso for the use of those who climb the mountain to worship. It is one of the beautiful features of the Japanese religion as practised by a great many of the people that it draws them out of doors and brings them in touch with nature. Almost every mountain is held in reverence, and many days during the course of the year are spent by the devout in excursions in the country or up into the mountains to pray on the high places.

It is a gentle ascent of only 200 or 300 feet from the rest house and the temples to the summit of the cone, first over a lava stream that looks as if it might have flowed but a little while before, then over a talus of lava, pumice and cinders, and finally over slippery, grey volcanic mud. At the top is the crater, a black, ragged, awful pit, roaring and steaming constantly. As one stands on the brink one looks down walls of roughly-stratified mud to a depth of 300 or 400 feet, where two round vents are continually rolling out masses of steam



FIG 6. LOOKING DOWN INTO THE MODERN CRATER OF ASO-SAN, showing the rough layers of mud in the walls and the bottom of one of the vents. Photo by Malcolm Anderson.



FIG. 7. LOOKING SOUTHEAST FROM THE STREAM ON THE FLOOR OF THE NORTHERN HALF OF THE OLD ASO CRATER OFF TO THE DIVIDING RANGE. A great vapor cloud rises from the new crater on the summit. In the center is Taka-dake, 4000 feet above the foreground, and on the left is part of Neko-dake.

and sulphur vapor and reverberating with explosive roars. This little crater has an oblong shape and is at a rough estimate 900 feet across and 2,000 feet long. Its rim is very uneven, being much higher on the north and east than on the other sides. It is divided into five compartments or vents, each separated from the other by a wall of mud, 100 feet or more high. The two already mentioned are the deepest and the only active ones, and occasionally, when the vapor column diminishes, one can look to the bottom of the northern vent and see the burning sulphur that plasters the lower walls and floor. The bottom is a round flat disc of cracked mud looking like the dried bottom of a pond, and there is no appearance of a hole or conduit descending to greater depths. The other of the two active crater holes is deeper and pours forth more steam. Its bottom can not be seen from any point upon the rim. The yellow sulphur fumes fill the air and become almost unbearable at times when the wind shifts the cloud a little towards one. We were able to follow the edge the whole way round the crater, a distance of about one and one half miles, but the going was difficult on account of the extremely slippery mud that forms the outer sides, which slope sharply away from the precipice on the interior. This soft, fine mud, both outside and inside the crater, is furrowed by rain and given a curious appearance. The other three vents, besides the two already mentioned, lie to the south along the axis of the crater. They are steep-walled, but not so deep as the other ones. They have flat bottoms of cracked mud, though in one the floor at the time of our visit was occupied by a shallow pool of water.

The view from points near the edge of the crater embraces a large part of the northern basin through a gap in the encircling heights on the north. But on all the other sides the rolling summit region is pretty well enclosed and looks a little as if it might have been at one time ages ago the site of a crateral basin much larger than the present active one.

At length the late hour and our extreme thirst after a warm day without water on these dry mountains drove us down from the heights. At the rest house by the temples we obtained a reviving drink of cold spring water, and on the bench where we sat to drink it we left all the change in our possession, which was a total of ten coins, amounting to nine tenths of a cent.

During the memory of man the crater on top of the Aso range has been active, and successive severe eruptions have again and again blown out ashes, cinders and bombs that have darkened the sky for many miles around and covered up the fields, have sent streams of mud mingled with hot water flooding down the mountain sides and over the plain, and caused terrifying noises and shakings of the ground. At such times crops and trees have been blighted and killed by the falling ash or by the heat and vapors, and the streams have been so

filled with *débris* and poisoned with bitter sulphurous water that the fish have died. Some say that the Shirakawa, which means 'white river,' owes its name to the milky color that it has been known to assume at such times. Loss of life has been occasioned by these outbursts, but the records do not make it clear to what extent. Reference is made in records to fiery rocks sometimes of great size that have been blown out, but lava flows do not seem to have assumed importance. Explosive eruptions of fine *débris*, as shown by the mud cone, have been predominant during the later history of the volcano.



FIG. 8. RECENT-LOOKING LAVA WITH SMOOTH FLOW STRUCTURE THAT HAS FLOWED DOWN A GULLY HIGH UP ON THE SOUTH SIDE OF NAKA-DAKE. In the distance, far across the great crater of Aso, may be faintly seen the horizon line of the outer wall. The whole foreground is covered with barren volcanic rock.

The greatest eruptions of very recent times were in the winter of 1873 to 1874, when unusual activity continued during several months and ashes covered the ground to a distance of 18 miles; in the winter of 1884, when ashes were blown over Kumamoto, making it so dark there at a distance of 25 miles that lamps had to be used for three days; in 1889, during the year of the Kumamoto earthquake, which was the year following the great explosions of Bandai-san in central Japan; and lastly in 1894, when the floor of the modern crater was somewhat altered.

The problem of old Mount Aso is a deep one. One can not view its gigantic outlines without wondering what forces could have molded them, what could have been the steps in the process of formation of this huge pit, its level floor, its steep walls, the gentle slopes radiating

from its outer rim, and of the rugged mountain bulwark in its center, on the summit of which the life of the volcano has been preserved in a far smaller inner crater. It seems inconceivable that processes alone of building-up could have resulted in such forms as those of Aso; and in attempting to outline its history one always reverts to some theory of destructive action on a very large scale.

The large crater of Aso may have been formed in either one of two ways, by the blowing off and away in some cataclysmic explosion, or series of explosions, the whole mass that must once have filled and overlain the present cavity, or by the sinking in of this same mass and its engulfment in a great void produced by the removal of the material that formerly gave support to the earth's surface at this point. A calculation, such as given below, of the mass displaced in either case affords an impressive sense of the magnitude of the task that was accomplished. The roughly-bedded strata in the walls of the big crater seem to dip away on all sides at a low angle, and their slope is probably reflected in the gently inclined surface of the outer plateau that forms the sides of the Aso cone. From the regularity of these slopes it seems likely that they represent the truncated base of an old conical mountain that continued upward with the present slope to a culminating point high above the center of what is now the crater bowl. It is probable that if such a mountain existed its upper portion rose with a gradually increasing slope into a peak, but even with a constant slope such as now exhibited in the base, its height would have been 7,000 to 7,500 feet above the sea, or about 6,000 feet higher than the present crater floor.

It is probable that during the early history of the volcano such a cone was built up by successive eruptions of lava and fragmental material that formed sheets one upon another down the sides and became roughly stratified in conformity with the slope of the mountain; and that before the close of the period of greatest activity of the volcano this cone was beheaded by some disruptive force. Not only was the summit removed, but the very heart of the volcano was opened, leaving a vast bowl on the site of the old eminence surrounded by the truncated lava flows of the outer circle of the mountain's base. Still later, the processes of building up recommencing, a new mountain was constructed, this time not over a single center as seems to have been the case before, but along the line of the short diameter of the former oval mountain, and in this way the present chain of peaks was raised. But the volcano was gradually dying down, and reconstruction on a grand scale ceased long before the new Aso had reached the dimensions of the old, or even effectually obscured, except to casual observation, the nature of its basal wreck.

The volume of the bowl of Aso, not subtracting the space that is taken up by the supposedly subsequent range, is at least nine cubic



FIG. 9. ONE OF THE MOST ACTIVE VOLCANOES OF JAPAN, KIRISHIMA-YAMA IN SOUTHERN JAPAN. From its summit, which is 6,000 feet high, may be seen Aso-san 70 miles away to the north.

*Titles of 9 and
interchanged*

miles. The mass that must once have overlain it, measured as the cone formed by the upward projection of the outer slopes, was at least 28 cubic miles in volume. Thus there must have been removed no less than 37 cubic miles, or about five and a half millions of millions of cubic feet of volcanic rock, a mass equal to over two and a half mountains like Vesuvius.

Furthermore the likelihood that the cone steepened toward its summit makes it possible that the old mountain was of greater size than estimated.

If we conceive of such a vast block of the earth's surface being blown up by some terrific explosion within the volcano, it is natural to suppose that great irregular deposits of the erupted material would be in evidence round the outside of the pit. There are immense areas of volcanic debris that have settled after being blown into the air, whole hills in places, within a radius of many miles of Aso. But these deposits seem to be regularly bedded and not to exhibit the rough and tumble structure that would probably result from their being tumultuously cast up by such a great explosion, and they do not form a rim around the crater rising above the old slopes of the cone. And further the walls of the pit seem to be too regular to have been explosively broken.

More acceptable appears the theory that the Aso crater is a sunken pit. A volcano of such magnitude must certainly have been underlain at some unknown depth by a large body of molten rock, the source of the lava that built up the cone. With all the weight exerted upon it by the overlying rocks and the pressure of steam from within, this fluid or viscous, intensely-heated mass must have sought violently for



KIUSHIU, AS SEEN FROM A DISTANCE. It has been in violent eruption during the last decade.

escape. Having, probably, found one or more points of discharge far below the summit of the cone, it flowed out in such vast quantities that it left a cavity large enough to engulf the whole of the unsupported mountain mass. The sinking was doubtless aided, and lessened in violence, by the partial fusion of the overlying rocks as they became more and more depressed, and probably the action took place around a common center. When the mountain summit had completely disappeared, there was left around about a regular curve of unbroken walls bearing witness to the comparative gentleness with which the action had been carried out. It is possible to consider the central Aso range as part of the old mountain that did not sink or become totally engulfed, but it seems more likely that it is a later growth. The completed work probably left the whole of the sunken mountain melted in a level lake within the great caldron. The radiating lava flows described in a later paragraph may help to account for the material removed.

After nearly two weeks spent in and about Aso we left it, setting out eastward to continue our march across Kiushiu to the Pacific, on the opposite side of the island from our starting point. The less precipitous portions of the crater wall are well-watered and clothed with beautiful groves of pines and cryptomerias, bamboos, oaks and chestnut trees, among which one finds little meadows and mossy places and banks overgrown with rich grass, where thrive an abundance of wild violets of various colors and sweet-smelling daphnes. Through these woods our road wound up out of the pit at a comparatively low and gently-rising portion of the wall, and finally over the crest of the rim to the far-sloping outer reaches. Within a few days more we

looked back at Aso from the top of Sobo-san, the highest mountain in the island, and appreciated more than ever the roundness of the crater and its great size, which can be better grasped from such a distance than from nearer at hand. The square, high block of Taka-dake and the turreted peak of Neko-dake stood impressively out of the huge bowl.

Some miles to the south and east of Aso-san the surface covering of volcanic ejectamenta which has filled up and blotted out the ancient features of the landscape ceases to be a solid sheet, but lava streams continue for great distances beyond, partly burying the old river channels that radiate away from the region occupied by Aso-san. Aso has evidently been the center of all the volcanic activity of this portion of Kiushiu, and the source of supply of the erupted material mantling the region. The longest of the lava arms follows the Gokase river for a distance of over 30 miles beyond the edge of the volcanic sheet as far as the sea, or a total distance of 50 miles from the volcano. It must have started as a broad stream or as successive streams of lava from Aso and have become narrowed into the old canyon of this river. The width of the present lava filling of the canyon is on the average $2\frac{1}{2}$ to 3 miles, and the depth amounts certainly to several hundred feet.

The Gokase-gawa runs to the east coast, and down its canyon we took our course after a few more days in the heart of Kiushiu. The



See fig. 10 FIG. 10. OVERLOOKING FROM THE HILLS THE BEAUTIFUL CITY AND BAY OF KAGOSHIMA IN SOUTHERNMOST JAPAN. In the deep bay stands the island volcano Sakura-jima, almost 4,000 feet high, another of the active volcanoes of Kiushiu. In 1863 this city was bombarded and partly burnt by an English admiral and his squadron. Again in 1877 it was set on fire during the last days of the Satsuma rebellion, and here at that time the final desperate stand of some of the Japanese nobility was made against the principle of Europeanization.

scenery was magnificent. High mountains rose on every hand out of the fairly wide and level bottom-land within the canyon. But this was not the old canyon bottom, it was the upper surface of the lava filling. We made this discovery on reaching the middle of the valley, where much to our surprise we came upon a tremendous gorge cut squarely out of it by the river, which is eating its way down again to find its old course. It has already reached a depth of 300 or 400 feet through the lava flow and has left a rift vertically walled on either side by columns of andesite that give a stately beauty to the cliffs. The river rushes down a steep channel, always growing with the addition of little tributaries, which tumble in over the parapet from out of jungles of greenery that overhang the edge and festoon the rocks with drooping purple tassels of wistaria. In its lower course it flows more quietly and widens, the rapids become less frequent and the canyon loses the intensity of its angles. But still the old lava flow continues. From the village of Takeshita, which means "below the falls," we took a rowboat and glided down the broad stream the rest of the way to the sea, away from the wild grandeur of the mountain scenery into the midst of the picturesque landscapes of the Japanese lowland.

